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plane, viz., conics having double contact with two fixed conics, etc., and in space, of conics touching six fixed planes, conics having double contact with three quadrics inscribed in the same developable, circles having double contact with two confocal quadrics, etc. These results are principally deduced by means of elliptic integrals and the first-class of hyper-elliptic integrals, and from them flow certain theorems concerning doubly infinite porisms of curvilinear polygons. This paper will be published in the *Bulletin of the American Mathematical Society*.

Professor Taber's paper related to the orthogonal transformations which leave a bilinear form unaltered, and their generation by means of infinitesimal transformations. It has been contributed to the *Quarterly Journal of Pure and Applied Mathematics*.

In Professor Hathaway's paper the proof consists in identifying, by means of elementary geometry, the product of several versors with the composition of a set of rotations through angles double those of the corresponding versors. The obvious associative principle of the composition of the rotations proves the corresponding associative principle of multiplication of versors. This paper will appear in the *Bulletin of the American Mathematical Society*. It was presented to the Society by Professor Shaw.

Professor Maschke's paper contains a very elegant application of elliptic functions to curves drawn on the surface of a circular ring. This paper will also appear in the *Bulletin of the American Mathematical Society*. It was presented to the Society by Professor Morley.

At the afternoon session, August 28th, two topics were presented to the Society for general discussion:

(1) 'A general subject catalogue or index of mathematical literature.'

(2) 'The mathematical curriculum of the college and scientific school.'

The first discussion was opened by the

Secretary, who gave a brief account of the '*Répertoire bibliographique des sciences mathématiques*,' in course of publication by the Mathematical Society of France. The discussion was continued by Professors Morley, Woodward and McMahon. On motion by Professor McMahon, it was resolved that the Council be requested to consider the desirability of offering to the Mathematical Society of France the coöperation of this Society and of drawing up a plan for such coöperation.

The second discussion was opened by Professor Shaw, who presented a table of statistics showing the character of the mathematical instruction in 101 representative colleges and scientific schools. The discussion was continued by Professors White, Morley, Van Vleck, Doolittle, Chandler, Pupin and Woodward. It seemed to be generally held that the work of the preparatory schools as a whole is not sufficiently thorough to serve as a satisfactory basis for collegiate courses; that a greater proportion of the students' time should be given to mathematical study; that greater stress should be laid on the fundamental subjects; that elementary portions of applied mathematics should be earlier introduced and more extensively taught, and that spherical trigonometry should be in great part, or altogether, dropped from the required curriculum.

At the close of the discussion the thanks of the Society were tendered to the Springfield Local Committee for the accommodations and hospitality which the Society had enjoyed, and the meeting was adjourned.

THOMAS S. FISKE.

COLUMBIA COLLEGE.

THE SPRINGFIELD MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

SECTION A. MATHEMATICS AND ASTRONOMY.

In section A, Mathematics and Astronomy, the following papers were read :

1. *Development of Some Useful Quaternion Expressions, with Applications to Geometry of Three and Four Dimensions*: JAMES BYRNIE SHAW.
2. *The Constant of Aberration*: C. L. DOOLITTLE.
3. *On the Constant of Nutation*: S. C. CHANDLER.
4. *Progress of the Zone Work at the Naval Observatory, Washington*: A. N. SKINNER.
5. *On the Distribution and the Secular Variation of Terrestrial Magnetism* (read by title): L. A. BAUER.
6. *Sun Spots and Magnetic Storms*: M. A. VEEDER.
7. *The Spectrum of B. Lyrae*: EDWIN B. FROST.
8. *Notes on Square Numbers Whose Sum Is Either a Square or the Sum of Other Squares*: ARTEMAS MARTIN.
9. *Some Results for Stellar Parallax from Meridian Transit Observations at the Washburn Observatory*: ALBERT S. FLINT.
10. *A Convenient Formula for Computing Times of Moon Rising*: EDGAR FRISBY.
11. *On a Slide Scale for Computing Precession*: EDGAR FRISBY.
12. *Chronology and Ancient Eclipses*: SAMUEL W. BALCH.
13. *Period of R. Comæ*: HENRY PARKHURST.

In his paper Professor Shaw develops the alternating functions, $A.pq = \frac{1}{2} (pq - qp,$

$S.p \text{ Aqr}$

$A.pqr = S.p \text{ Aqr} - Sp. A. qr,$

$-Sq. Arp - Sr. Apr,$

$S.p \text{ Aqrs}.$

A set of four quaternions related to one another is deduced, analogous to a set of three rectangular unit vectors and from which various collections of formulas can be derived.

Affixing one of the set of four quaternions to each vertex of a tetrahedron and letting the point $P = x_1 l_1 + x_2 l_2 + x_3 l_3 + x_4 l_4$ be that point for which the volumes $BC, P - BCD, P - CDA, P - DAB, P - ABC$ are as $x_1 : x_2 : x_3 : x_4$ we are enabled to treat solid geometry projectively.

The elaborate and carefully arranged series of observations made by Professor C. L. Doolittle at Lehigh University, primarily for the determination of the variation of latitude, was planned by him so that a determination of the constant of aberration could also be secured, stars being taken

throughout all the 24 hours, and the pairs being observed before and after midnight so as to obtain maximum aberration coefficients, with opposite sign. This series was observed from 1892, October 10, to 1893, December 27, 442 nights.

Professor Doolittle finds for the constant of aberration

$20.''55,$

Struve's value being $20.''44$. Later values differ considerably from that of Struve, and it would appear that his value is too small.

Dr. Chandler, on examining Pond's Greenwich mural circle observations with the idea of getting at the long period term of the variation of latitude, found the work to be of excellent quality, quite as good as the modern work, though imperfectly reduced. The plan of observation was first-rate, being so arranged as to eliminate as far as possible division errors, flexure and all instrumental constants. Indeed, Dr. Chandler regards the discovery of the good quality of this work as a most important one. From Pond's observations is found for the constant of lunar nutation

$9.''190,$

the usual value, called Peters', being

$9.''223.$

Peters observed only a few stars and took no account of the long period variation of latitude. It is probable that the constant of lunar nutation is very nearly

$9.''20,$

since Professor Newcomb finds for this constant from the Greenwich transit circle declinations and the Washington transit circle declinations respectively

$9.''194,$

$9.''204.$

It should be noted that Dr. Chandler's discussion of Pond's mural circle declinations confirms Boss' proper motions as being almost exact.

A number of years ago the German Astronomical Society inaugurated the plan of making fairly accurate determinations of the stars in the *Durchmusterung* of Arge-landler and that of Schönfeld. The sky was divided into bands or zones, every zone overlapping for comparison purposes on the zones north and south.

Mr. Skinner gave an account of the work on the zone — $13^{\circ} 50'$ to — $18^{\circ} 10'$ which had been assigned to the Naval Observatory, and which is now being observed there under his charge. Zero stars are distributed throughout the zone, the other stars being determined differentially with respect to them. Each star is to be determined at least twice. The work has now been going on for a year and a half. The zone has been observed in one position of the instrument, and 5,714 stars in the reversed position, the whole number of stars being more than 8,000. Probably the observing will be completed next winter and it will be about two years after that before the reductions are finished.

Dr. Veeder is doing excellent work collecting statistics with regard to auroras, magnetic storms and thunder storms, and endeavoring to derive general laws. It is to be hoped that many observers may be found who will furnish him the data he desires.

The problems regarding the spectrum of β Lyræ as brought to light by recent spectroscopic observations of this star at Pulkova, Potsdam and London were treated by Professor Frost.

Mr. A. S. Flint, of the Washburn observatory, presented some results of the researches with regard to stellar parallax undertaken by him with the Repsold meridian circle of that observatory by the method of Kapteyn. A list was made of stars having a proper motion of $1''$ or more. A large number of these stars Mr. Flint has observed for three epochs, and he proposes to continue until he shall secure five. As to the

method of observing a bright field was used and wire screens were employed so that all stars should appear in the telescope as approximately of the same brightness. The observations were begun 1893, October. The method of Kapteyn, which is differential, employing a preceding and following comparison star, is certainly excellent. Mr. Flint has obtained important results of a high order of accuracy.

ASAPH HALL, JR.

SECTION E. GEOLOGY AND GEOGRAPHY.

EIGHTEEN papers were presented to the section this year, but only thirteen were read in full, as the authors of the others were not present at the meeting. Major Jed. Hotchkiss, of Staunton, Va., the Vice-President, was absent from the early sessions of the section, so that his address was not delivered until Monday afternoon. He then gave a somewhat informal talk on the geological survey of Virginia, 1835–1841, and its influence on the history of science in this country. This survey was conducted by Professors W. B. and H. D. Rogers and was held by the speaker to have been the first important geological survey carried on in the United States. The work was carried on for five years at an expense of only \$100,000 and the results lie at the foundation of the progress made in geology since.

'The relations of primary and secondary structures in rocks' was the topic discussed by Professor C. R. Van Hise, of Madison, Wis. The paper inquired into the relations of cleavage and fissility to bedding, and showed that in homogeneous rocks the law of hydrostatic viscous flow applies, and therefore that the secondary structure cuts the primary. In heterogeneous rocks the beds are of varying strength, and the accommodations between them control the major movements, which are parallel to them. The secondary structure is produced